G3: Low latitude ionosphere effects on systems and radio propagation.

Observations of E-region field-aligned irregularities off the magnetic equator, using the Piura VHF radar

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Introduction

We have used the Piura VHF radar (5°12'S, 80° 38'W, ~7.5° N geomagnetic latitude, just outside the magnetic equator) in northern Peru to gather echoes from 3-m E-region field-aligned irregularities (FAI). Similar irregularities have been intensively studied in the equatorial and auroral zones using ground-based radar systems and in-situ (rocket-borne) probes. Mid-latitude E-region FAI have been the subject of far fewer experiments over the years, however this situation is rapidly changing and multi-instrument experiments are being conducted and planned [1]. On the other hand at low-latitudes but outside the equatorial electrojet (EEJ), i.e., >±3°, there have been not many radar observations, only those reported from a recent backscatter experiment in India [2], and the 1958 forward-scatter experiments in South America [3]. It will be important to compare our radar observations to the better known irregularities at neighboring latitudes (equatorial and mid-latitude), in order to see the possibility of inferring some of the physical mechanisms governing the off equatorial FAI. The Piura radar is part of a wind profiler network in the tropical Pacific. The main purpose of this system is to study the lower atmospheric dynamics. However, in order to observe the E-region FAI, we interrupt the normal operations of the radar. Coincidentally, we can do our observations by using one of the pre-defined antenna-pointing positions.

Observations

Our preliminary observations, based on a 15-day campaign taken in October-November 1996 and on previous short period observations since 1991, show that the E-region FAI over Piura are confined to the 95-120 km altitude and present spectral characteristics similar to type 2 EEJ echoes. However, they appear mainly at nighttime and early morning, therefore, do not present a temporal similarity to EEJ. Moreover, we observe the existence of two well-defined types of echoes: 1) lower E-region echoes (95-105 km), and upper E-region echoes (105-120 km). Recently we have conducted a 20-day campaign in October-November 1998 with the intent to corroborate our initial observations, and to improve our current understanding. For example, this time we have made our observations with a higher time resolution. The higher time resolution has allowed us to clearly separate E-region echoes from meteor echoes. Preliminary analysis of this data set indicates that at this low-latitude site we could be observing quasi-periodic (QP) echoes. However our QP echoes present, most of the time, a vertical and a positive slope rather than the negative slope observed with the MU radar. Similar vertical and positive slopes have been recently observed with the Chung-Li radar in Taiwan [4].

References

[1] Fukao et al., Geophys. Res. Lett., vol. 25, no. 11, pp. 1761, 1998.
[2] Murthy et al., J. Geophys. Res., vol. 103, pp. 20761-20772, 1998.
[3] Cohen and Bowles, J. of Res. NBS, vol. 67D, pp 459-480, 1963.
[4] Pan and Tsunoda, Geophys. Res. Lett., vol. 25, no. 11, pp. 1809-1812, 1998.

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[4] [illegible], vol. 25, no. 11, pp. 1809-1812, 1998.

Radar Studies in Puerto Rico of Mid-latitude E-region Plasma Instabilities

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During the summer of 1992 a radar and rocket campaign (El Coqui) was undertaken to study plasma instabilities associated with nighttime sporadic-E layers. We observed with the 430 MHz Arecibo incoherent scatter radar (ISR) and the 50 MHz CUPRI (Cornell University Portable Radar Interferometer) system, operated simultaneously as much as possible and sometimes looking at the same scattering volume. The ISR was usually run in a scanning mode, at a 15^0 zenith angle and sweeping through 90^0 in azimuth. CUPRI was directed perpendicular to the magnetic field and 35^0 or 57^0 west of magnetic north (46^0 or 68^0 W geographic). There was a single transmitting antenna but three receiving antennas for CUPRI, providing both horizontal and "vertical" baselines so we could determine the angular location of strong, localized echoing centers. The antenna half-power beamwidths were about 5^0 in the horizontal plane and about 30^0 in the vertical. The CUPRI pulse lengths were either 30 or 50 μs. The coded pulses used in the ISR measurements had a baud length of 1 or 4 μs, giving an altitude resolution of 150 or 600 m.

We wished to study the relationship between the electron density profile measured by the ISR, especially the layer structure in the nighttime E region, and the VHF echoes from unstable plasma waves aligned with the magnetic field. We succeeded in getting completely coincident data from the two systems only occasionally, but we were able to draw a number of conclusions. Of particular interest were our observations of QP (quasi-periodic) echoes that are a common feature of similar radar studies in Asia (e.g., the SEEK campaign; see numerous papers in *Geophys. Res. Lett.*, *25*, No. 11, June 1, 1998). We saw only a few QP echoes, but these were interesting. Each set persisted for only 20-30 minutes, in contrast to an hour or more for Asian echoes. We saw examples of both approaching and receding echoes, in contrast to SEEK which saw only negative slopes (approaching irregularities) in height-time-intensity plots. Again in contrast to SEEK, our Doppler velocities were sometimes opposite in sign to the rate of change of range of the echoes. From our interferometry data we determined that the echoes always came from a band of altitudes no thicker than 20 km and that these altitudes never exceeded 120 km. SEEK, on the other hand, reported altitudes several scale heights higher. The SEEK altitudes were less directly measured, however, because there was no interferometry data.

Our ISR data showed no sign of strong gravity wave activity associated with any of the irregularity observations. There were invariably sporadic-E layers at about the same altitude or altitudes from which echoes were received, but there was little evidence of substantial (several km) wave-like ripples in these altitudes.

Observations of *E* Region Field-aligned Irregularities just Outside the Equatorial Electrojet Region

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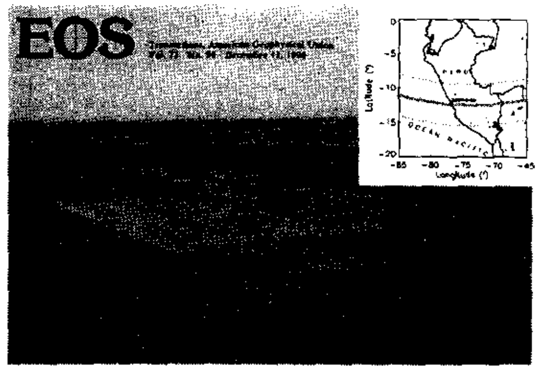
[2]Laboratorio de Física, Universidad de Piura, Piura, Perú
(@ ISEA-10, Antalya, Turkey, May-2000)



Contents

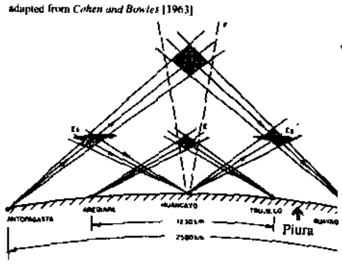
- Motivation
- General characteristics
  - First observations
  (from *Woodman et al.*, [1999], *Radio Sci.*,34, 983-990).
  - New observations.
- Quasiperiodic echoes
  (from *Chau and Woodman*, [1999], *Geophys. Res. Lett.*, 26, 2167-2170.)
- Future studies

Motivation

- To verify some *E* region characteristics obtained during the IGY (1958) with a VHF forward-scatter configuration.
- New and therefore interesting from a scientific point of view.
- To get statistics needed for the design of a wireless communication system.
- To study a possibility of an equatorial spread *F* (ESF) seeding mechanism.

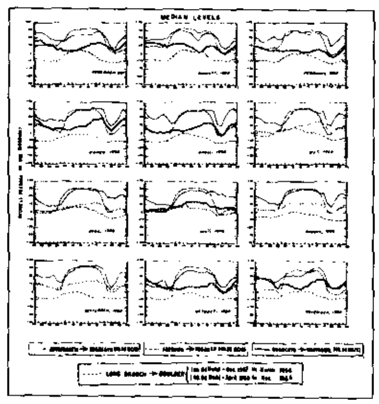
IGY experiment: Configuration

adapted from *Cohen and Bowles* [1963]



IGY Experiment: Results

(from *Cohen and Bowles*, [1963])

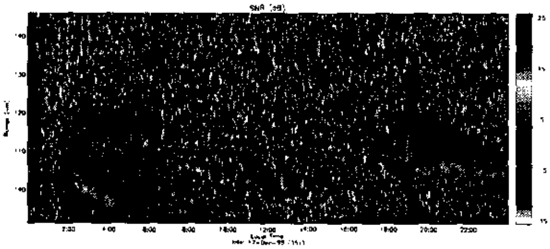


IGY Experiment: Conclusions

(de *Cohen and Bowles*, [1963])

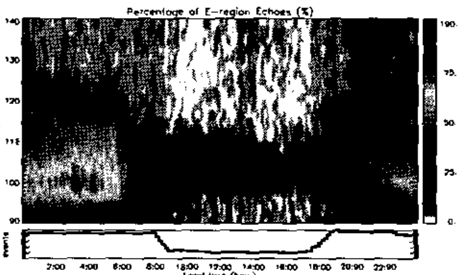
- *E* region echoes at $5°N_m$:
  - were weaker than those observed at the magnetic equator and at $5°S_m$, independent of the season .
  - absent, most of the time, during the day.
- ...

SNR measurements



Diurnal Characteristics

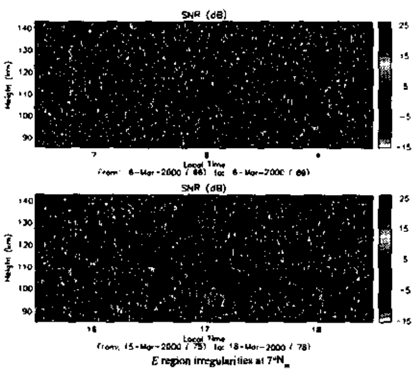
1995 (Jul, Aug, Dec); 1996 (Oct, Nov);
1998 (Jul, Oct, Nov); 1999 (Feb, Apr, Jul, Aug, Oct).



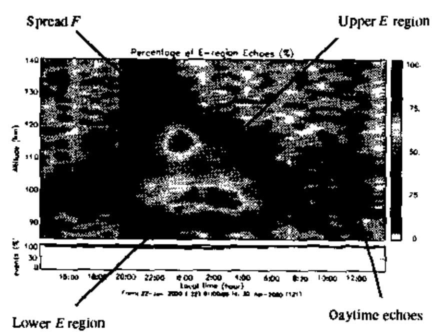
Summary from first observations

- They appear after 1800LT and disappear before 0800LT. In few occasions appear during the day sporadically.
- Spectral characteristics are similar to EEJ type 2 (small Doppler, wide spectral widths).
- Two regions are observed:
  - Lower echoes (~95 to 105 km, all night). One or two layers of 3-5-km thickness. Close-to-zero mean Doppler velocities.
  - Upper echoes (~105 to 120 km and between 22 and 06 LT)
    - "Patchy" fashion.
    - Positive mean Doppler velocities (Downward/southward).
    - Narrower spectral widths than the lower echoes.

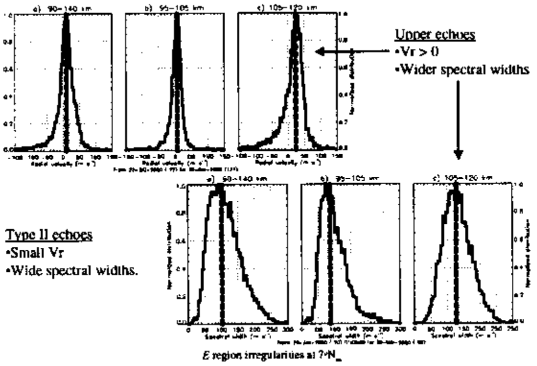
New observations



New observations: Diurnal Characteristics

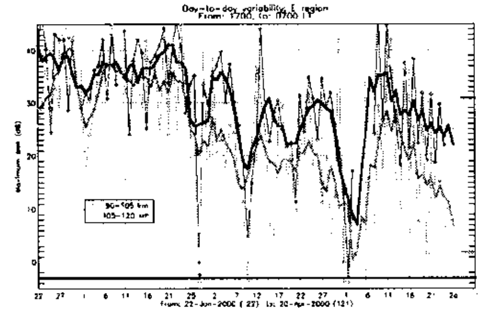


New observations: Histograms



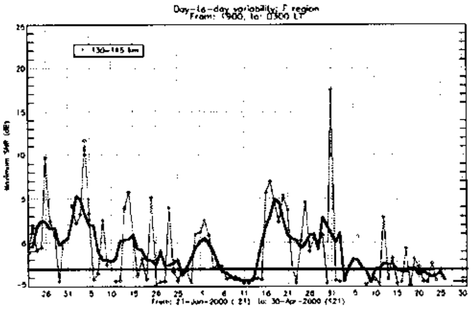
E region irregularities at 7°N$_m$

New observations: *E* region Day-to-Day variability



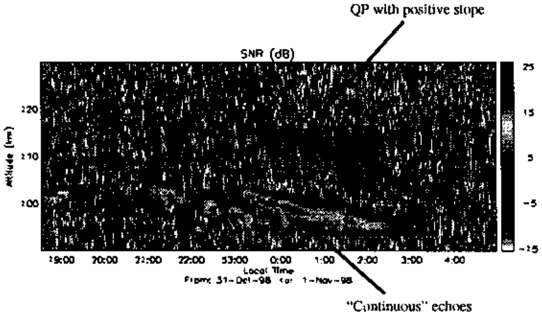
E region irregularities at 7°N$_m$

New observations: *F* region Day-to-Day variability



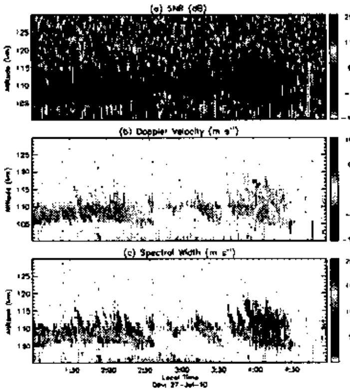
E region irregularities at 7°N$_m$

Quasiperiodic echoes



E region irregularities at 7°N$_m$

Quasiperiodic echoes: Negative slope



E region irregularities at 7°N$_m$

Quasiperiodic echoes: Characteristics

- Periods between 5 and 10 minutes.
- Confined to the 105-120 km.
- Spacing of striations is short (between 3 and 10 km).
- Striations present, mainly, positive slopes (Upward/northward). In some occasions, vertical and negative slopes have been also observed.
- Mean Doppler velocity is positive (Downward/southward).
- Appear mainly between 22 and 06 LT (result infer from first observations).

E region irregularities at 7°N$_m$

Quasiperiodic echoes as observed at different latitudes

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shigaraki, Japan [illegible]	34.9°N, 48.6°	Yes	No	Yes	95-125	2-10	Negative	VHF
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tanegashima, Japan [illegible]	30.4°N, 43.2°	Yes	No	Yes	90-140	5-10	N/A	HF
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Stanford, USA [illegible]	37.4°N, 61.3°	Yes	No	No	90-140	5-10	N/A	HF
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Piura, Perú [illegible]	5.2°S, 13.9°	Yes	Yes	Yes	105-120	5-10	Positive	VHF
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

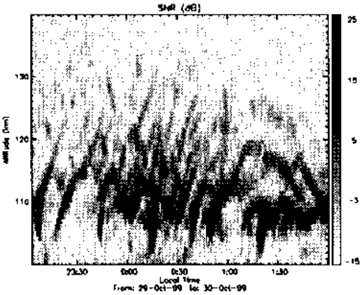
E region irregularities at 7°N$_m$

Future Studies

- Statistical studies from continuos observation (e.g., day-to-day variability, seasonal variability).
- Relationship between *E* and *F* region irregularities over Piura and over Jicamarca.
- Imaging experiments on campaign basis.

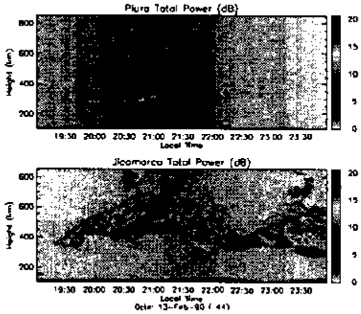
E region irregularities at 7°N$_m$

Quasiperiodic echoes?



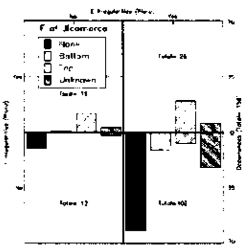
E region irregularities at 7°N$_m$

F over Piura vs. *F* over Jicamarca



E region irregularities at 7°N$_m$

E vs. *F* region irregularities: Summary of statistical occurrence



E region irregularities are observed over Piura most of the time.

When *F* irregularities are observed over Piura, "Top" *F* irregularities are observed at Jicamarca.

When there are no *F* irregularities over Jicamarca, *F* irregularities are not observed at Piura.

E region irregularities at 7°N$_m$